AT THE ENTERPRISES AND INSTITUTES

UDC 666.22:535.317.2

USAGE PROPERTIES OF CONSTRUCTION GLUE FOR PRECISION ASSEMBLY OF PRISMATIC OPTICAL MODULES

V. V. Potelov[1]

Translated from *Steklo i Keramika*, No. 5, pp. 35 – 36, May, 2009.

Several types of construction glue and their usage properties in the production and assembly of high-precision optical hardware with glass – metal bonding are examined.

Key words: glue, prismatic modules, optoelectronic hardware.

As a rule, modern optoelectronic systems are high-precision multifunctional complexes which include precision mirror-prismatic multicomponent units [1]. The most promising production direction for such units is the development of glued structures that make it possible to meet the requirements imposed on them:

obtaining the prescribed position of the parts to a high degree of accuracy;

reliable mounting;

reducing to a minimum the deformation occurring in optical parts under climatic and mechanical effects;

positional stability and stability of the optical characteristics within prescribed limits during operation;

improvement of mass/size characteristics.

Experience in developing and operating various glued structures shows that glass – metal bonds are most problematic because of the low stability of the spatial positions of the optical components and inadequate shear and detachment strength, instability of the technology used to produce glued structures, and few choices for the glue to be used.

The Federal Center for Science and Technology "S. A. Zverev Krasnogorsk Works" JSC and the Federal State Unitary Enterprise "All-Russia Scientific – Research Institute of Aerospace Materials" have jointly conducted research on the physical and mechanical properties of existing types of promising glue for glass – metal bonds; tests of glued control samples using glue that had been optimized on the basis of the results of mathematical simulation were performed, adjustments were made and additional development work was performed on existing material, and promising glue for attaining the required technical characteristics was investigated and tested.

Technical Characteristics of Glue

Birefringence (after gluing and tests), nm/cm	No more than 25
Deformation of the working surface of an optical component (deviation from planarity)	No more than $\lambda/4$ ($\lambda/4 = 650$ nm)
Working temperature range where accuracy characteristics are maintained, °C	From – 60 to + 70
Strength, MPa:	
shear	At least 6
uniform detachment	At least 12
nonuniform detachment	At least 3
Service life, yr	At least 12

High-precision optical components are fabricated using parts which are made from dissimilar materials with different CLTEs (glass, titanium alloy) and assembled by gluing [2]. As a rule, K-8 optical glass with a high degree of uniformity and low birefringence is used to fabricate high-precision individual components of assemblies. The titanium alloy VT-1-0 is used to make mechanical parts.

Glue possessing high adhesion to silicate glass as well as high strength and elasticity can be used to glue these materials together. A necessary condition for reducing to a minimum the internal stresses which arise in the glue seam after glass and metal are glued together is that the glue must remain elastic.

[1] Federal Center for Science and Industry "S. A. Zverev Krasnogorsk Works," Krasnogorsk, Moscow Oblast, Russia.

0361-7610/09/0506-0189

TABLE 1.

Indicator	Glued materials	Test temperature, °C		
		– 60	20	80
Strength, MPa:				
shear	D16, abrasion	22.0	24.5	9.0
	D16AT, anodic oxidation in chromic acid	22.0	24.8	10.7
	D16AT, anodic oxidation treatment in sulfuric acid	14.0	23.5	9.0
	OT-4, comminution	26.0	27.0	9.5
	30KhGSA, comminution	26.0	27.5	10.0
	30KhGSA, cadmium plating	–	28.5	6.4
detachment	D16AT, anodic oxidation treatment in chromic acid	45.0	38.0	9.5
	30KhGSA, comminution	50.0	37.5	6.5
nonuniform detachment	D16AT, abrasion	3.2	4.4	1.6
	D16AT, anodic oxidation treatment in chromic acid	3.5	4.5	2.2

The vibrational stability under shear of the glued materials was also determined. This was done with cycle asymmetry coefficient $r = 0.1$ ($r = \sigma_{min}/\sigma_{max} = 0.1$) and vibrational frequency $f = 2000$ cycles/min. The vibrational stability under shear of D16AT materials glued (anodic oxidation in chromic acid) using VK-87 glue is presented in Table 2.

The next stage of the work was devoted to studying the deformation properties of VK-27 glue under uniform shear.

Characteristics of VK-27 Glue Under Uniform Shear at 20°C

Strength, MPa 27.0
Shear modulus, MPa . . . . 270 – 540
Relative elongation, % . . . . 50 – 125

To this end a series of investigations of the physical – mechanical characteristics of VK-27 and K-300-61 glues with a KLT-300 sublayer was conducted to determine the effect of these glues on the operational stability of the optical characteristics and longevity of glued optical assemblies.

Chemical Nature of Glues in with a KLT-300 Sublayer

VK-27 . . . . Epoxy – rubber
K-300-61. . . . . Based on epoxy resin, modified by polyorganosiloxane, and polyamide resin

The glue hardens virtually with no shrinkage at room temperature as well as at 60°C without secondary products being released, forming a composition with high physical – mechanical characteristics.

Standard samples which had been glued together were tested in the initial state as well as after being exposed to thermal, vibrational, and mechanical loads. The mechanical properties of the bonds obtained with VK-27 glue at low, normal, and elevated temperatures are presented in Table 1.

TABLE 2.

Test temperature, °C	Maximum stress in a cycle, MPa	Number of cycles to failure
20	12.5	104
	10.0	105
	7.5	106
	6.5	107
80	4.6	104
	3.5	105
	2.4	106
	1.5	107

Samples of the aluminum alloy D16AT with a coating deposited by anodic oxidation in chromic acid and the titanium alloy OT-4 were glued together with K-300-61 glue in order to determine the shear strength. The results of the tests are presented in Table 3.

The glue bonds obtained between aluminum and titanium alloys using K-300-61 glue withstand heat aging at temperatures 200 – 300°C. The strength of glue bonds after standing for 20 days in an atmosphere with 98% humidity is 15 MPa.

The increase of the shear strength of the glue bonds at negative temperature (– 60°C) shows that the glue is very stiff. Consequently, it is recommended this glue be used with an organosilicon elastic sublayer KLT-300 to secure optical components to metal mounts and substrates.

The characteristics of K-300-61 glue used with a KLT-300 elastic sublayer (test temperature 20°C) to glue K-8 glass to VT1-0 titanium alloy are as follows: shear strength — 3.3 MPa and uniform detachment strength — 2.1 MPa.

In summary, the bonds obtained with VK-27 and K-300-61 glues possess high vibrational stability and long-time strength; they are highly water-proof and are distinguished by stability of the mechanical properties in air at elevated temperatures as well as by stability under tropical conditions.

TABLE 3.

Alloy	Shear strength, MPa, at test temperature, °C		
	– 60	20	80
D16AT	25.8	12.5	6.0
OT-4	24.0	15.0	6.5

The VK-27 glue is much stronger than K-300-61 glue with a KLT-300 sublayer and at the same time quite high elasticity.

The K-300-61 glue is stiff. For this reason, to secure optical components to metal it can be used only with an elastic KLT-300 layer so that no deformation would exceed the required magnitude.

To obtain the required bonding strength and deformation characteristics in optical assemblies the glues VK-27 and K-300-61 with a KLT-300 elastic sublayer must be used taking account of their physical – mechanical characteristics and deformation properties as well as the construction of the optical assemblies.

REFERENCES

1. S. A. Arkhipov, V. V. Potelov, and B. N. Senik, "Characteristics of the technology for fabrication of high-precision optical prismatic units and spectrum-dividing modules," *Opt. Zh.*, **71**(12), 11 – 13 (2004).
2. A. Kucheiko, "Japan has built the largest space exploration system," *Novosti Kosmonavt.*, No. 4, 34 – 37 (2007).